

- Paleoenvironmental Implications of Clay Minerals at Yellowknife Bay, Gale Crater, Mars

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The Mars Science Laboratory (MSL) Rover, Curiosity spent ~150 sols at Yellowknife Bay (YKB) studying a section of fluvio-lacustrine sedimentary rocks (with potential indications of volcanic influence), informally known as the Yellowknife Bay formation. YKB lies in a distal region of the Peace Vallis alluvial fan, which extends from the northern rim of Gale Crater toward the dune field at the base of Mt Sharp. Sedimentological and stratigraphic observations are consistent with the Yellowknife Bay formation being part of a distal fan deposit, which could be as young as middle Hesperian to even early Amazonian in age (~3.5 to 2.5 Ga). The Yellowknife Bay formation hosts a unit of mudstone called the Sheepbed member. Curiosity obtained powdered rock samples from two drill holes in the Sheepbed Member, named John Klein and Cumberland, and delivered them to instruments in Curiosity. Data from CheMin, a combined X-ray diffraction (XRD)/X-ray fluorescence instrument (XRF), has allowed detailed mineralogical analysis of mudstone powders revealing a clay mineral component of ~20 wt.% in each sample. The clay minerals are important indicators of paleoenvironmental conditions and sensitive recorders of post-depositional alteration processes. The XRD pattern of John Klein reveals a 021 band consistent with a trioctahedral phyllosilicate. A broad peak at ~10Å with a slight inflexion at ~12Å indicates the presence of 2:1 type clay minerals in the John Klein sample. The trioctahedral nature of the clay minerals, breadth of the basal reflection, and presence of a minor component with larger basal spacing suggests that John Klein contains a trioctahedral smectite (probably saponite), whose interlayer is largely collapsed because of the low-humidity conditions. The XRD patterns show no evidence of corrensite (mixed-layer chlorite/smectite) or chlorite, which are typical diagenetic products of trioctahedral smectites when subjected to burial and heating >60°C in the presence of water. Given estimated geothermal gradients on Mars temperatures <60 °C might still be consistent with (but do not require) moderate burial. However, our ability to identify interstratified minerals is greatly limited by the lack of access to traditional treatments methods used in the lab (e.g., ethylene glycol solvation). Our preferred explanation for the origin of trioctahedral smectites in Sheepbed mudstone is in situ production via reaction of olivine, water and Si-bearing amorphous material, an important mudstone component detected by XRD. Elevated levels of magnetite in the Sheepbed and the trioctahedral monomineralic nature of the clay minerals support this model. These observations, combined with previous studies of olivine stability, support the persistence of circum-neutral hydrous conditions for thousands of years at YKB.